

LINKAGES IN PRACTICE

A REVIEW OF THEIR CONSERVATION VALUE

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Published by: IUCN, Gland (Switzerland) and Cambridge (UK) in collaboration with Syzygy, Nijmegen (Netherlands)

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Citation: Graham Bennett. 2004. *Linkages in Practice: a Review of Their Conservation Practice*. IUCN, Gland (Switzerland) and Cambridge (UK). 28 pp.

ISBN: 2-8317-0774-9

Illustrations:

Page 11: Image courtesy Australian Coral Reef Society, written and produced by Russell Kelley (russellkelley@mac.com), design by Gavin Ryan (GavinRyan@toadscape.com)

Pages 19–21, Cascade Corridor diagrams: Danah Duke, Miistakis Institute for the Rockies

Page 22, photographs: Brendan Godley, University of Wales

Page 23, map: Programme Régional de Conservation de la Zone Côtière et Marine d'Afrique de l'Ouest

Graphic design by: Marc Hegemans

Printed by: ATAR Roto Presse, SA
Vernier (Switzerland)

Available from:

IUCN Publications Services Unit
219c Huntingdon Road
Cambridge CB3 0DL
United Kingdom
Tel.: +44 1223 277894
Fax: +44 1223 277175
E-mail: books@iucn.org
www.iucn.org/bookstore

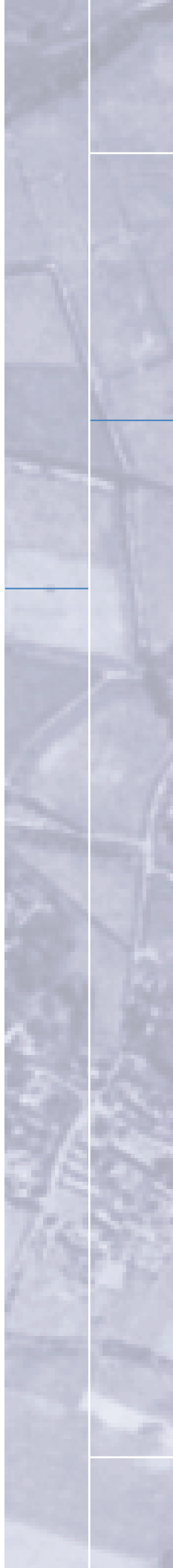
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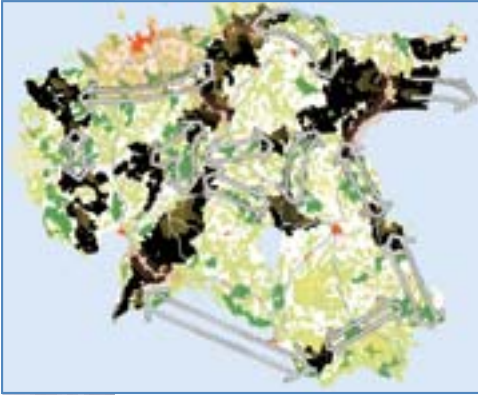
CONTENTS

- 7 Introduction
- 8 Reviewing the value of linkages
- 9 Why linkages?
- 10 Types of linkage
- 11 Assessing experience with linkages
- 12 Four examples of linkages
- 25 Conclusions
- 26 Further information
- 28 Acknowledgements



INTRODUCTION

In an ideal world it could be argued that people would confine their activities to islands of settlement and to the margins of ecosystems, leaving natural areas large enough to ensure their continued integrity. But we do not live in such a place. In the real world the pressures of population growth and economic development severely disrupt natural systems and force us to find ways to reconcile human needs with the conservation of biodiversity.



As a result of this concern, awareness is growing of the need to find ways of maintaining the coherence of ecosystems in response to the fragmentation caused by human activities. An increasing number of conservation initiatives around the world are therefore aiming to create or restore functional linkages between protected areas and their surrounding regions. This includes building extensive linked systems at the landscape scale.

The basis of this work are the theoretical notions developed through island biogeography, metapopulation theory and landscape ecology, concepts that have been brought together in the discipline of conservation biology. However, it is not always clear how generic notions of ecological coherence can effectively be applied to conservation practice on the ground. The array of variables that apply to each particular situation is unique, and scientifically assessing the effects of conservation action requires a lengthy monitoring period and also involves intractable methodological challenges, such as the need to isolate each variable and to replicate experimental work.

There is nevertheless one overriding reason why an evaluation of practical experience with linkages is justified even if it cannot meet all the requirements of scientific rigour: namely, the urgency of the conservation challenge. Quite simply, we cannot afford to wait. The task is therefore to determine the extent to which current work on strengthening ecological connectivity provides evidence that linkages offer added conservation value.

REVIEWING THE VALUE OF LINKAGES

Ecologists agree that, as a rule, increasing ecological coherence enhances the essential structure, processes and functioning of ecosystems, improves the interaction between organisms and their environment and strengthens the resilience of ecosystems when responding to stress. The theme of connectivity has been on the agenda of IUCN for many years and a range of initiatives that aim to strengthen ecological coherence have been undertaken. IUCN's World Commission on Protected Areas (WCPA) and the Commission on Ecosystem Management (CEM) are actively involved in these initiatives. Both Commissions are keen to move beyond theory and improve their understanding of how linkages can help conserve biodiversity in practice.

This, however, is easier said than done. Wildlife corridors, for example, have for many years been the subject of a lively debate on the real conservation value that is delivered by connectivity. In the light of that debate, and to forestall any misunderstandings, it should be emphasized that in this publication the term 'linkage' will be used to denote a functional ecological connection that may take on a variety of forms – not simply a linear corridor connecting two areas of habitat.

The main purpose of this review is to assist WCPA and CEM in understanding the practical value of maintaining, enhancing, creating or restoring linkages rather than to assess the theoretical underpinnings of connectivity. However, it is worth reiterating three premises that have been derived from the connectivity debate and which enjoy broad support:

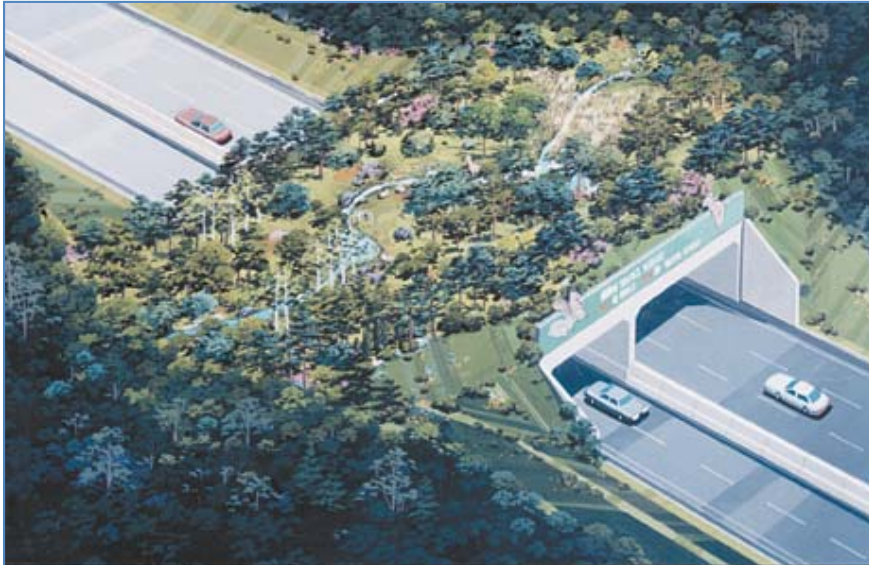
- ▶ *until recently most species populations lived in well-connected landscapes, and the present level of ecological fragmentation is therefore anomalous*
- ▶ *habitat loss and fragmentation are the main threats to biodiversity and are crucial issues to be resolved if we are to secure the conservation and sustainable use of biodiversity*
- ▶ *enhancing ecological connectivity has the potential to increase the long-term viability of many species populations.*



WHY LINKAGES?

Until well into historical times, a high level of connectivity existed among ecosystems. Through the ever-increasing extent and intensity of human exploitation of natural resources, however, the pattern of human activities as islands in a sea of nature has become reversed in most of the world's regions. Habitat fragmentation is now one of the most important causes of the decline in biodiversity.

This is not to say that the absence of connectivity is a serious and immediate threat to all forms of biodiversity. Indeed, for many species, such as most plants, physical linkages with other patches of their habitat are not the most crucial determinant of their survival. For viability in the long-term, however, ecological coherence is important to a wide range of species.



In fragmented landscapes, there are five main reasons why linking isolated patches of habitat can help increase the viability of local species populations:

1. *It allows individual animals access to a larger area of habitat – for example, to forage, to facilitate the dispersal of juveniles or to encourage the recolonization of 'empty' habitat patches.*
2. *It facilitates seasonal migration.*
3. *It permits genetic exchange with other local populations of the same species (although this only requires very occasional contact).*
4. *It offers opportunities for individuals to move away from a habitat that is degrading or from an area under threat (which may become increasingly important if climate change proves to have a serious impact on ecosystems).*
5. *It secures the integrity of physical environmental processes such as periodic flooding that are vital to the requirements of certain species.*

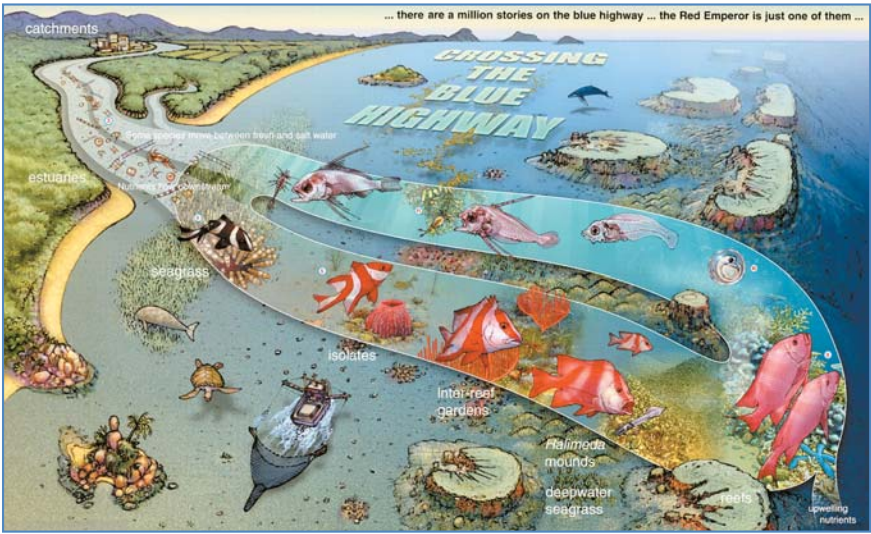
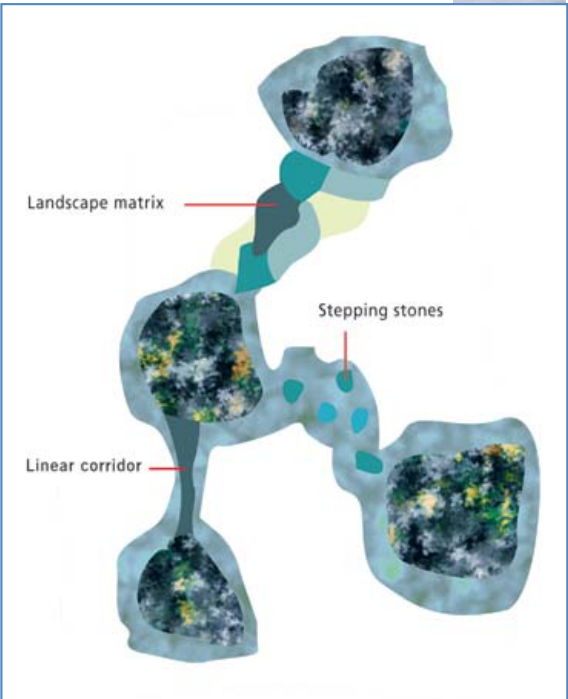
TYPES OF LINKAGE

Linkages can take many different forms. In general, there are three broad kinds of landscape linkage:

- ▶ a linear corridor (such as a hedgerow, forest corridor or river)
- ▶ ‘stepping stones’, that is, an array of small patches of habitat that species use during movement for feeding and resting
- ▶ various forms of landscape matrices that allow a species to survive during movement between habitat patches.

The linkage concept also applies to the marine environment, albeit it in a rather different and more limited way. There are three main kinds of linkages in seascapes:

- ▶ marine corridors (such as straits that are used by certain species during migration, for dispersal or to move between spawning and feeding grounds)
- ▶ estuarine linkages, that is, the eco-systems formed by the interaction between a river and the sea
- ▶ coastal linkages, where species such as turtles and seals depend on littoral shallows or the presence of a coast-line.



The scale at which ecological connectivity takes place varies widely. It includes local movement (such as the need for toads to cross a road in order to reach their spawning ground) as well as global events, such as the pole-to-pole migration undertaken by the arctic tern (*Sterna paradisaea*).

ASSESSING EXPERIENCE WITH LINKAGES

Linkages have been the subject of growing interest for about 20 years and are increasingly being included in biodiversity conservation programmes around the world. However, the growing importance attached to connectivity is largely based on theoretical notions; it is surprisingly difficult to demonstrate how linkages function in practice and the extent to which they contribute to the conservation of biodiversity.

Much of this difficulty concerns the degree to which a linkage, once established, can be shown to deliver the intended conservation benefit:

- ▶ *Do we know whether individuals would have succeeded in crossing the barrier if the linkage had not been created?*
- ▶ *Are we sure that the observed presence of individuals in a linkage actually means that movement is taking place between the habitat patches (rather than the linkage simply being used as additional habitat, for example)?*
- ▶ *Has the monitoring programme extended over a long enough period to unequivocally establish the value of the linkage?*
- ▶ *Are there other hypotheses that would explain the observed movement (such as human activity or exceptional weather conditions)?*
- ▶ *Does the linkage have negative ecological effects (such as creating a route for fire or invasive alien species)?*
- ▶ *Is a linkage the most cost-effective way of achieving the conservation objective (as opposed, for example, to enlarging a protected area or promoting biodiversity-compatible land uses)?*

Establishing to a sufficiently high degree of confidence that a linkage functions as intended can involve a long, intricate, intensive and expensive monitoring programme. Moreover, the results should be able to be replicated in comparable situations. Given the limited resources that are available to most conservation programmes, however, it is usually impossible to allocate a substantial proportion of the available funds to a lengthy monitoring programme and to delay further actions pending the results. Greater reliance therefore has to be placed on modelling and on practical experience in conserving particular species populations.

FOUR EXAMPLES OF LINKAGES

The large number of linkages being established around the world provide a valuable resource for new linkage initiatives. This broad range of experience can be illustrated by four examples, each of which has been well documented. They are located in diverse environments and also encompass the four main kinds of movement that linkages aim to promote:

- ▶ **local movement** (to forage, for example)
- ▶ **dispersal** of individuals to other habitat patches
- ▶ **nomadism** by wide-ranging species
- ▶ **seasonal migration**.

Moreover, the examples illustrate four different types of linkage:

- ▶ an ecoduct across a motorway
- ▶ stepping stones across a human-exploited landscape
- ▶ a regional corridor
- ▶ a coastal linkage.



WOESTE HOEVE

Linking Fragmented Habitat for Deer and Wild Boar by Ecoduct



The Veluwe



In the centre of the Netherlands, within the lower reaches of the Rhine delta, lies an area known as the Veluwe. Formed during the last glaciation, the Veluwe comprises a raised, dry and sandy core surrounded by a wet, nutrient-rich margin. The vegetation in the central part is mainly woodland – planted to a large extent during the twentieth century – but also includes the largest area of heathland in Europe. Most of the surrounding lowlands are farmed. In a densely populated, industrialized country such as the Netherlands, the Veluwe is both an exceptionally valuable natural system and an important area for recreation. It is for this reason that much of the area now falls within two national parks.



The species diversity of the Veluwe is of special value; no other area in the country has such a rich native fauna. In particular, it is one of the few areas in the Netherlands where large mammals can still be found. These include red deer (*Cervus elephus*), fallow deer (*Cervus dama*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*).



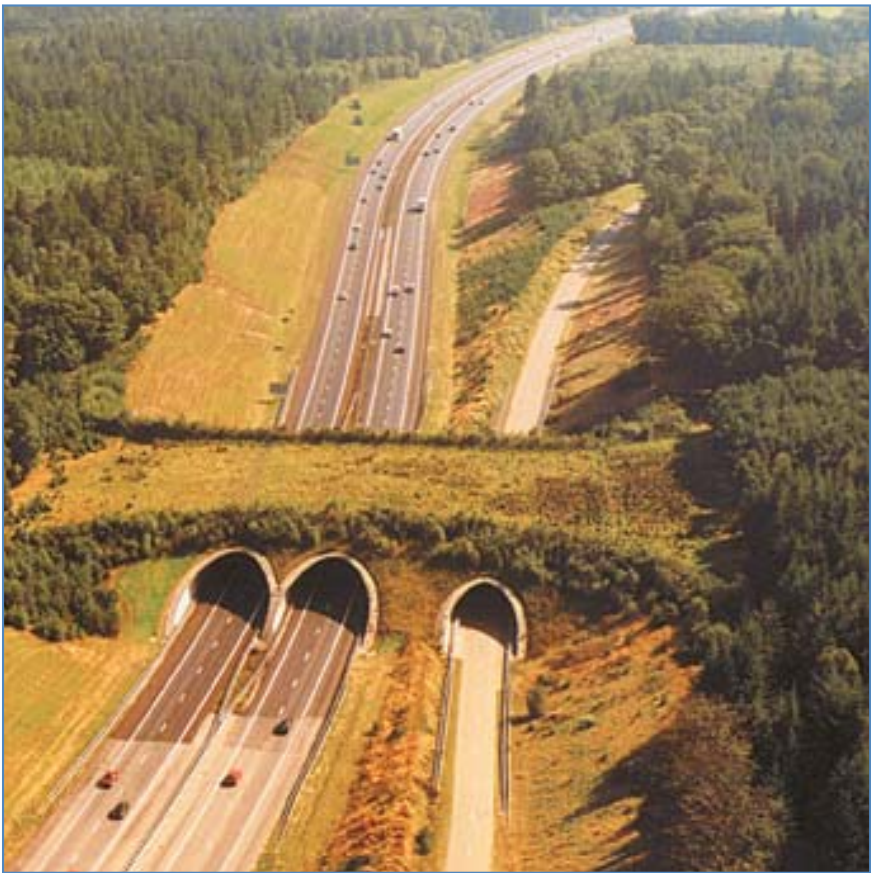
One of the most serious threats confronting these animals is the increasing fragmentation of their habitat. Roads, railways, expanding agriculture, military training grounds and fenced hunting grounds have increasingly restricted the larger mammals' opportunities to range across the Veluwe.

Another barrier to movement was created in 1988, when an existing two-lane road between Apeldoorn and Arnhem was upgraded to a four-lane motorway. Because the motorway was fenced to prevent the incursion of large animals onto the road, the populations of large mammals in the southeastern corner of the Veluwe became isolated from the main populations in the centre of the region.

The potential negative effects of the motorway on the fauna of the Veluwe caused considerable controversy during the 1980s, and as a result extensive assessments were undertaken to determine which measures could be taken to reduce these impacts. The outcome of the work was a decision to build two ecoducts across the new motorway: 'Woeste Hoeve' and 'Terlet'.



The Veluwe



The Woeste Hoeve] ecoduct



Because the plans for the ecoducts were based on estimates of their likely effectiveness – rather than documented experience with similar linkages in the region – it was decided to monitor their use intensively immediately following the completion of the motorway. The distribution of red deer on both sides of the road was surveyed in 1987–1988 in order to establish a baseline for the monitoring programme.



The Woeste Hoeve ecoduct is about 140 metres long and 50 metres wide. It is planted with grass, and hedgerows screen both edges. In order to attract animals to the ecoduct, pools were excavated near both entrances. The linkage connects the older forests on the east of the road with younger woodland on the west.

Monitoring the use of the ecoduct took place over a twelve-month period from January to December 1989. A strip of loose soil was laid across the centre of the ecoduct to record the footprints of passing animals. In addition, human observers recorded passages twice a week. This provided additional data on passages that did not leave clearly identifiable footprints, the approximate age of the animals and the extent to which the animals were grouped when they used the ecoduct. Aborted passages could also be noted.

The monitoring programme commenced within two months of the new motorway being opened, and the results showed that the ecoduct was used regularly by all the large mammals for which it was intended. The red deer used the ecoduct throughout the year as a linkage; the local resident populations of fallow deer and roe deer used it not only for that purpose but also as additional habitat, feeding off the vegetation. Wild boar and also badgers used the ecoduct at a more or less constant rate throughout the year.

The results of the monitoring exercise demonstrate that the linkage functioned as expected. It is particularly interesting that the large mammal species used the ecoduct almost immediately after the motorway was opened. Although the results cannot be used to determine the long-term viability of the deer and wild boar populations, the fact that older and richer forest habitat to the east of the road was not isolated from the central area of the Veluwe certainly prevents a decline in both the extent and the quality of the habitat available to the main populations.

THE SILVER-SPOTTED SKIPPER BUTTERFLY
Recolonization Through Stepping Stones

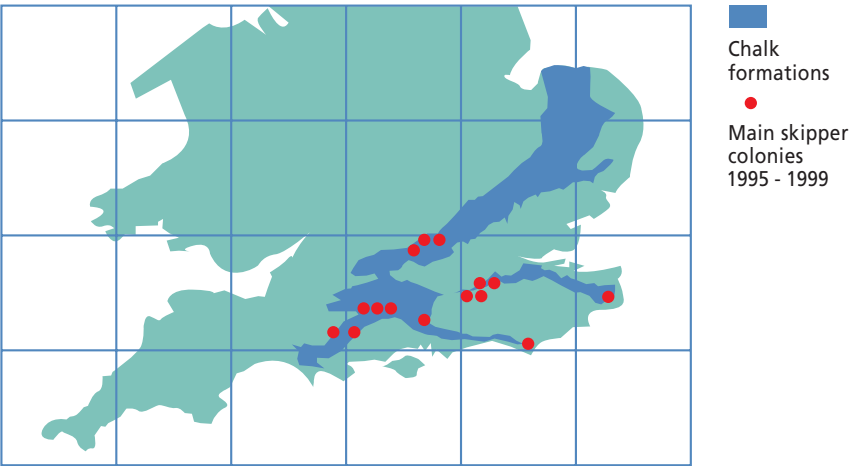


The silver-spotted skipper is a butterfly found in temperate regions of Europe, North Africa and Asia. Several subspecies are also found in North America. The butterfly's preferred habitats are dry or calcicolous grasslands and heathlands where its larvae breed exclusively on sheep's fescue (*Festuca ovina*). The creation and maintenance of these habitats are dependent on grazing by both livestock and rabbits (*Oryctolagus cuniculus*).

In the UK, the butterfly was historically widely distributed across southern and eastern England. The progressive conversion of unimproved grasslands to arable land reduced the available habitat during the first half of the twentieth century, restricting its range to the southern chalklands. Worse, in the 1950s rabbit populations were ravaged by the viral disease myxomatosis, causing many areas of grassland to become overgrown. As a result, the distribution of the silver-spotted skipper contracted to just 46 sites in ten regions.



The silver-spotted skipper



Distribution of the silver-spotted skipper in the UK



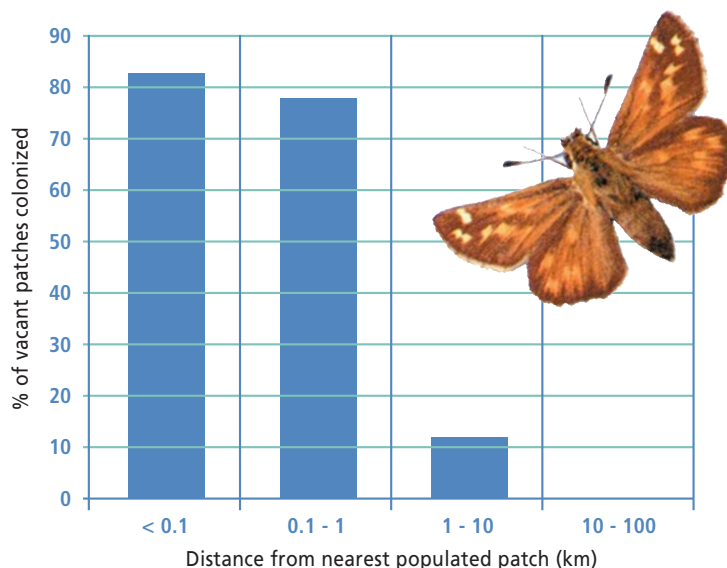
Calicolous grassland

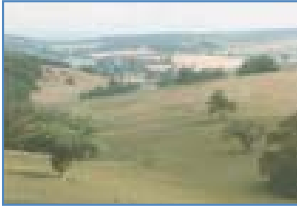
In the succeeding years, rabbit populations gradually recovered from myxomatosis and livestock farming expanded so that many areas of grassland were once more grazed. New areas of suitable habitat became available to the remaining populations.

A characteristic feature of the silver-spotted skipper is that its small local populations have high immigration and emigration rates. These small populations cannot therefore be regarded as self-sustaining colonies. The combination of the availability of new habitat and the special dispersal needs of the species were important factors when studying the way in which the butterfly recolonized the restored habitat.

A monitoring programme carried out in the period 1982–1991 showed that the silver-spotted skipper colonized 29 ‘empty’ habitat patches and disappeared from ten occupied patches, while over 100 apparently suitable habitat patches remained unoccupied. Analysis of the spatial dynamics of the butterfly’s dispersal showed that the probability of colonization depended above all on two factors:

- ▶ *the greater the distance of the habitat patch from an occupied patch, the lower the probability of colonization, and*
- ▶ *the larger the habitat patch, the higher the probability of colonization.*





The first factor – the distance between an occupied and an empty patch – proved to be more important. Indeed, no direct colonizations were recorded where two habitat patches were more than 8.5 kilometres apart.



Another notable finding of the monitoring programme concerned local extinctions. The probability that the butterfly would become extinct in an occupied habitat patch was inversely related to the likelihood of colonization; that is, the smaller the distance

between occupied habitat patches and the larger the area of a particular patch, the less probable was local extinction. In relating the probability of local extinction to the size of the local population of the silver-spotted skipper, it was found that small populations – those with fewer than 225 individuals – were vulnerable to extinction. None of the local populations that were greater than 225 individuals in 1982 became extinct during the following nine years of monitoring.

The findings on the distance between suitable unoccupied habitat patches, the size of the patches and the size of local populations indicate that the dispersal of the butterfly is facilitated by the existence of proximate arrays of habitat patches. Where the patches are less than 8.5 kilometres apart, they function as stepping stones across the landscape. More recent work has confirmed the need to maintain extensive networks of habitat patches, particularly where the patches are smaller than five hectares and cannot permanently support an isolated local population of the silver-spotted skipper.



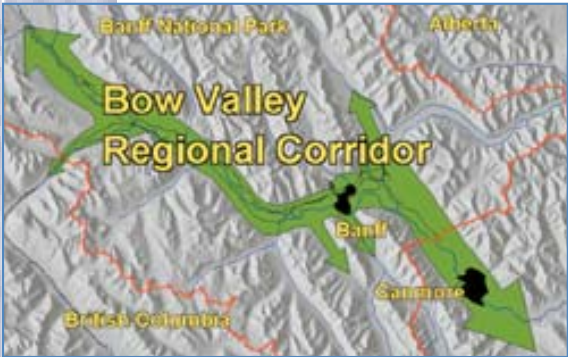
WOLVES IN THE CANADIAN ROCKIES

Restoring a Regional Corridor



The Rocky Mountains are North America’s last remaining intact mountain ecoregion. Although the Rockies retain their full complement of native species, local extinctions and endangered species are causing serious and increasing concern. Among the most striking of the species under threat are the large carnivores: pumas (*Felis concolor*, also known as the cougar or mountain lion), grizzly bears (*Ursus arctos horribilis*), wolverines (*Gulo gulo*) and wolves (*Canis lupus*). Mainly as a result of habitat destruction and hunting, potentially viable populations of these animals are now found only in the small number of protected areas in the region’s northern stretches.

The wolf is a good example of the special needs of these large carnivores. Wolves require access to exceptionally large tracts of habitat; one individual, for example, was tracked moving from the Flathead Valley in Montana to Mile 0 on the Alaska Highway, a distance of 840 kilometres. Because none of the existing national parks is large enough as a single unit to support a viable population of wolves, the long-term survival of the animal depends on its ability to move freely between the islands of habitat that remain. Urban development and new roads may dissuade wolves from moving into areas of suitable habitat that they had previously used, however, and can lead to their permanent abandonment.



In the central Canadian Rockies, the rugged nature of the terrain forces wolves to confine their movements to low-lying valley bottoms. Rivers and passes therefore function as natural corridors. This can clearly be seen in the Bow River Valley in Alberta’s Banff National Park, a linkage that offers the highest-quality habitat for wolves in the central Canadian Rockies and permits the movement of wolf packs between Canada and the US.

The valley was recolonized by wolves during the 1980s, but increasing development – urban settlements, major roads and recreation facilities – severely disrupted the opportunities for wolves to move through the valley. This forced them to adopt circuitous, energy-intensive and less suitable alternative routes and to abandon some high-quality habitats.



The Cascade Corridor



Banff

The corridor offering the greatest potential for movement through the Bow Valley is the Cascade Corridor, one of three routes around the town of Banff that are available to wolves. The Cascade Corridor lies about one kilometre to the north of the town, is about six kilometres long and varies in width from 350 to 1500 metres. Vegetation cover is about 50 per cent open forest, 30 per cent closed forest and 20 per cent open meadow.



The corridor is especially important to wolves during the winter months when their prey – mainly elk (*Cervus elephus*) and mule deer (*Odocoileus hemionus*) – move down to lower elevations and the Cascade wolf pack roams across the lower Bow River Valley. Wolves made little use of the route before 1997 because of the

moderate-to-high level of human intrusion in the corridor, which included a hotel, ski access road, buffalo paddock, barns, horse corrals, an airport and a military training facility. Because of the regional importance of the corridor in facilitating the movement of wolves, however, Parks Canada (the management authority of the national park) agreed to take action to reduce the intensity of human activities. As a result, in 1997 the buffalo paddock and several barns and horse corrals were removed and the airstrip was closed to all air traffic except emergency landings. These actions also reduced associated recreational activities and vehicle use in the corridor.



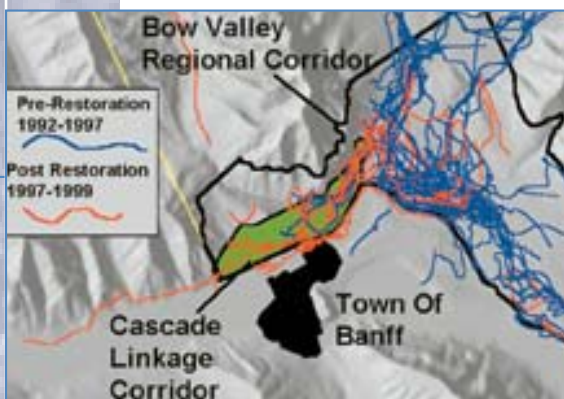


A programme to monitor wolf movements in the Bow River Valley had been underway for several years and had already provided extensive tracking data through the use of radio collars, with additional data being provided from analyses of snow tracks and kills of the wolf's prey species. Reducing human activities in the Cascade Corridor offered an excellent opportunity to determine the effect of the restoration actions on the wolves' movement patterns. The results were striking.



Using the overall intensity of wolf movements within the Bow River Valley as a baseline, relative movement through the Cascade Corridor increased sevenfold in the period 1997–1999 compared with the period 1993–1997, an increase far greater than had been hypothesized. Moreover, not only was the intensity of movement through the Cascade Corridor far greater, the improved connectivity seemed to allow the Cascade wolf pack to expand its range: the home range of the pack increased in extent to include four more valleys, expanding in range from 607 to 1847 square kilometres.

21



Tracking data for the periods 1992–1997 and 1997–1999

Since the monitoring programme only extended over a relatively short period, it was possible that other incidental factors – such as variations in snowfall and the abundance and location of prey – could have been partly or wholly responsible for the increased movement of the wolves. Analysis of these factors, however, showed that the recorded variations during the monitoring period did not explain the observed changes in use of the corridor. The results confirmed that the restoration of the Cascade Corridor recreated a linkage that is crucially important for wolf packs in the region.

GREEN TURTLES IN WEST AFRICA

Identifying a Vital Marine Linkage

The green turtle (*Chelonia mydas*) is found mainly in the tropics. Only seven major nesting colonies of the turtle's Atlantic-Mediterranean population have been identified and the species is classified by IUCN as endangered. The largest turtle rookery in West Africa is found on the island of Poilão off the coast of Guinea Bissau, and it is considered to have global importance. Although the exact size of the population is not known, in 1995 a total of 1650 females were tagged during the nesting season.



The colony on Poilão has always been relatively free from serious threat by human activities; not only is the island relatively remote, it is also regarded as a sacred site by the local Bijagós culture. In addition, in 2000 the area was included in Guinea Bissau's first marine protected area: the João Vieira-Poilão Islands Marine National Park. In recent years, however, evidence has suggested that the turtle population is declining. The main causes seem to be the harvesting of eggs and incidental catches of turtles by both traditional fishing and the rapidly expanding industrial fishery. Since the green turtle is a migratory species, preventing further impacts on the colony requires an understanding of its life cycle and range. In 2001 a project was undertaken to track the movements of a number of turtles, with the objective of identifying the most important marine areas used by them.



The green turtle



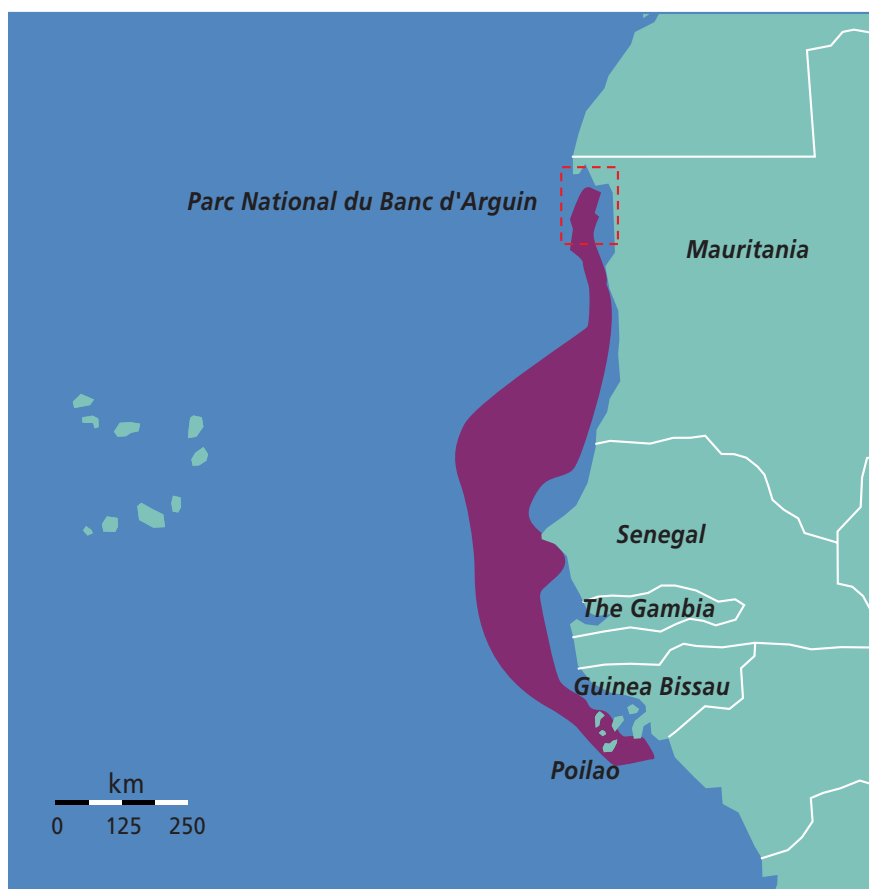
The island of Poilão

In order to track the movements of the turtles, small satellite transmitters were fitted to ten females, which were then tracked until the transmitters failed. The results provided the first detailed information on the local and migratory movements of Poilão island green turtles.



The João Vieira-Poilão Islands Marine National Park

Four females were tracked to the Park National du Banc D'Arguin in Mauritania, with the data showing the coastal routes that they travelled. Two more females were tracked to Senegalese coastal waters before their transmitters failed, one individual returning to within 60 kilometres of Poilão. The transmitters of the four remaining females failed while the animals were still in the vicinity of Poilão and their destinations could not therefore be ascertained, although one female was tracked moving towards the mainland and then returning to Poilão to lay a second clutch of eggs. The data suggest that these turtles made use of foraging, interesting and migratory habitats within the archipelago, which supports local anecdotal evidence.



The migratory corridor used by the green turtles

The significance of the results is that, by providing a first indication of the movements and range of the Poilão turtle colony, they establish a focus for further conservation action. Thus, in addition to demonstrating that the turtles use other parts of the archipelago, the migratory linkage between Poilão island and the Park National du Banc D'Arguin has been identified.

Although the number of individuals that were tracked was small and further monitoring work will be necessary to properly understand the ecology of the green turtle, it is already clear that international collaboration will be necessary to ensure that human activities, such as industrial-scale fishing, do not affect this linkage. The findings support the existing steps that have been taken to promote international collaboration to conserve the region's coastal environment. They will also help strengthen the effectiveness of management measures being developed within the framework of the João Vieira-Poilão Islands Marine National Park, the Bonn Convention on Migratory Species – under which a Memorandum of Understanding to conserve West African turtles has been adopted – and the Regional Strategy for Marine Protected Areas in West Africa that was finalized by six West African states in 2003.

CONCLUSIONS

Although this review provides only four examples of the way in which linkages function in practice, viewing these examples in the context of the broader literature on connectivity enables a number of conclusions to be drawn on the value of linkages for biodiversity conservation.

Documented benefits. The increasing body of evidence from well-documented and monitored programmes shows that appropriately designed linkages generally meet the expectations of how they will function in practice. It should be stressed that most of this evidence falls short of providing scientific proof that the linkages improve the long-term viability of the respective species populations. The conditions required to establish beyond doubt that the linkages achieve this objective – particularly with regard to experimental replication and long-term monitoring – are in most cases neither feasible nor fundable. However, providing strict scientific proof on how a linkage functions is not necessarily essential to be able to draw conclusions with an acceptable level of confidence.

Few negative effects. The documented cases show very few instances where a linkage causes damaging conservation effects, such as establishing a route for an invasive alien species. This is not to say that such examples do not exist, but on the basis of the literature it can be concluded that they are the exception rather than the rule.

Cost-effective. Most of the documented examples of linkages suggest that establishing or maintaining the connection was the most cost-effective means of achieving the conservation objective. Again, for most examples this conclusion is not based on a rigorous experimental analysis of all possible alternatives. In many cases, however, the linkage was demonstrably the only feasible and practicable option to achieve the conservation objective; in other cases, alternative courses of action – such as enlarging a protected area – would have involved serious problems.

Limited scope to generalize results. The complexity of the factors that determine how each specific linkage functions should make us wary of generalizing practical experience. Although conservation biology offers useful theoretical insights into the value of linkages, there is no substitute for good local understanding of how ecosystems function and of the specific threats that should be reduced.

Understanding the results. A proper understanding of how a linkage functions requires that it be correctly designed and that a monitoring programme is in place. For example, it may not be clear from observations whether a linkage facilitates the movement of a species between habitat patches or whether individuals simply occupy the linkage because it provides additional habitat. The special requirements of monitoring programmes need to be determined and taken into account before any linkage is established.

Preventing fragmentation. One aspect of the linkage debate that is often overlooked is that an improved understanding of connectivity can help *prevent* the damaging fragmentation of relatively pristine regions when their natural resources are opened up to exploitation. Understanding how the ecosystems function enables us to ensure that critical linkages are maintained, which is an essential condition for securing the sustainable use of biodiversity.

If one overall conclusion can be drawn from the increasing experience with linkages, it is that the results to date support the more extensive application of well-designed linkages, particularly for species populations that are threatened, wide-ranging and fragmented. The growing body of evidence that substantiates many of the theoretical notions regarding ecological connectivity is therefore providing us with a powerful tool to secure the conservation and sustainable use of biodiversity.

FURTHER INFORMATION

The Woeste Hoeve Ecoduct

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ACKNOWLEDGEMENTS

The preparation of this review benefited considerably from the cooperation and suggestions of many associates.

- ▶ Herman Linde of the Dutch National Forestry Service willingly gave up a Sunday afternoon to guide me around the Woeste Hoeve ecoduct and discuss its construction and functioning.
- ▶ Danah Duke, Executive Coordinator of the Miistakis Institute for the Rockies, enthusiastically responded to my proposal to include the Cascade Corridor case in the review, made her research results available and commented on a first draft.
- ▶ Brendan J. Godley of the University of Wales' Marine Turtle Research Group kindly agreed to the use of material from the Group's study of West African green turtles.

The review was first presented to IUCN's World Parks Congress that was held in Durban, South Africa, on 8–17 September 2003. The members of the Congress's 'Linkages in the Landscape and Seascape' team contributed substantially to the review when it was first presented and subsequently supervised its publication. I am particularly grateful to Peter Bridgewater, Secretary-General of the Ramsar Convention Secretariat, Marieke Wit of IUCN's Ecosystem Management Programme and Sebastia Semene of the Ramsar Convention Secretariat. Patricia Halladay improved the readability of the text and contributed to the presentation of the material.

Finally, the preparation of the review would not have been possible without the financial support made available through IUCN for the World Parks Congress, particularly from the US Fish and Wildlife Service and the Global Environment Facility.



LINKAGES IN PRACTICE

A REVIEW OF THEIR CONSERVATION VALUE

Graham Bennett

The negative impact of habitat fragmentation on biodiversity has stimulated a growing interest in the role of ecological connectivity. This interest is manifested in the increasing number of biodiversity conservation initiatives that incorporate physical linkages into their design. IUCN, through the World Commission on Protected Areas and the Commission on Ecosystem Management, is actively involved in many of these initiatives and is keen to improve understanding of how linkages can help conserve biodiversity in practice. IUCN is aware, however, that ecological connectivity has for many years been the focus of a lively debate on the real conservation value that linkages can deliver. This review is intended to summarize and to inform that debate. Drawing on the literature on connectivity, it presents the main issues that need to be addressed, uses four well-documented cases to illustrate how linkages can function in practice and draws conclusions from these examples and from broader experience.

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